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(54) **CASING JOINT ASSEMBLY FOR PRODUCING AN ANNULUS GAS CAP**

(71) Applicant: **Landmark Graphics Corporation**, Houston, TX (US)

(72) Inventor: **Robert F Mitchell**, Lookout Mountain, GA (US)

(73) Assignee: **Landmark Graphics Corporation**, Houston, TX (US)

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This patent is subject to a terminal disclaimer.

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E21B 43/10	(2006.01)
E21B 17/08	(2006.01)

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CPC ***E21B 41/00*** (2013.01); ***E21B 17/08*** (2013.01); ***E21B 34/06*** (2013.01); ***E21B 43/10*** (2013.01)

(58) **Field of Classification Search**

USPC 166/332.1, 75.13, 90.1, 373

See application file for complete search history.

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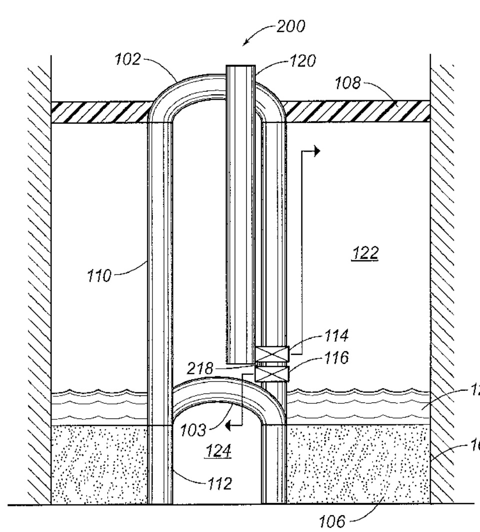
Primary Examiner — Taras P Bemko

(74) *Attorney, Agent, or Firm* — Crain, Caton & James; Tenley Krueger

(57) **ABSTRACT**

A casing joint assembly and methods for producing an annulus gas cap using the casing joint assembly. The casing joint assembly comprises a first valve and a second valve to control fluid pressure in the sealed annulus between the casing string and a wall of the well bore or another casing string.

5 Claims, 2 Drawing Sheets



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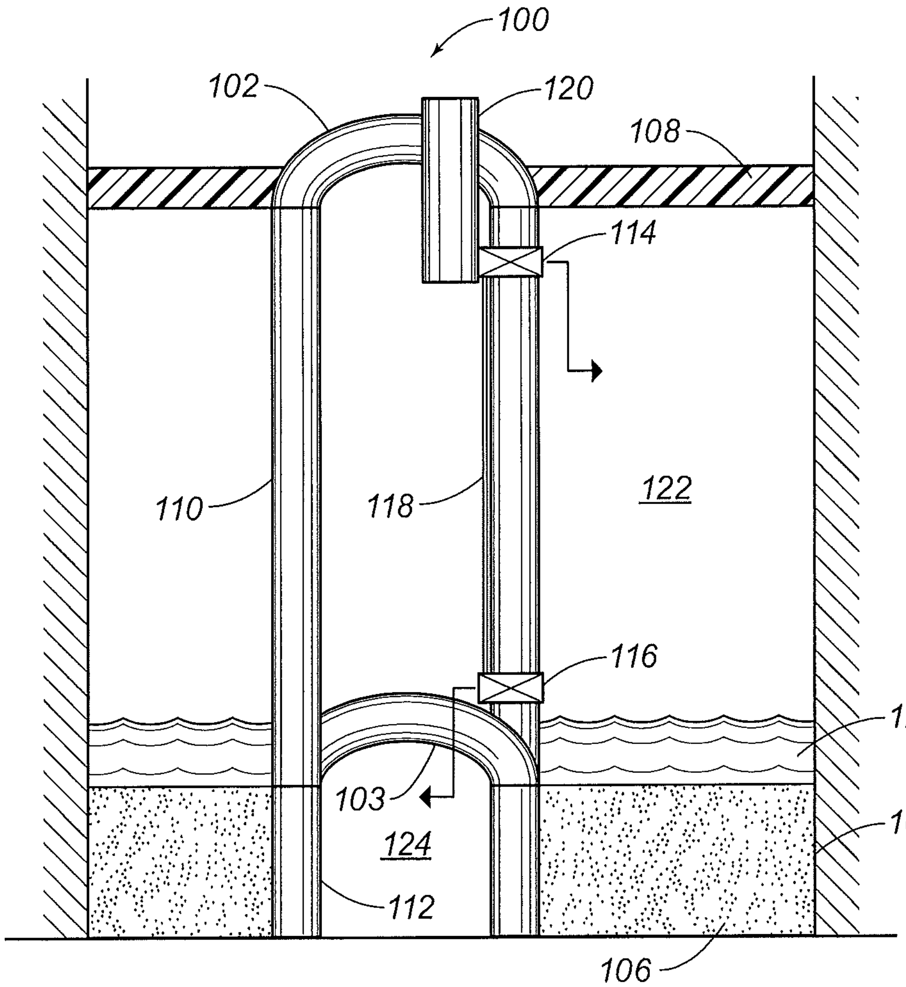

FIG. 1

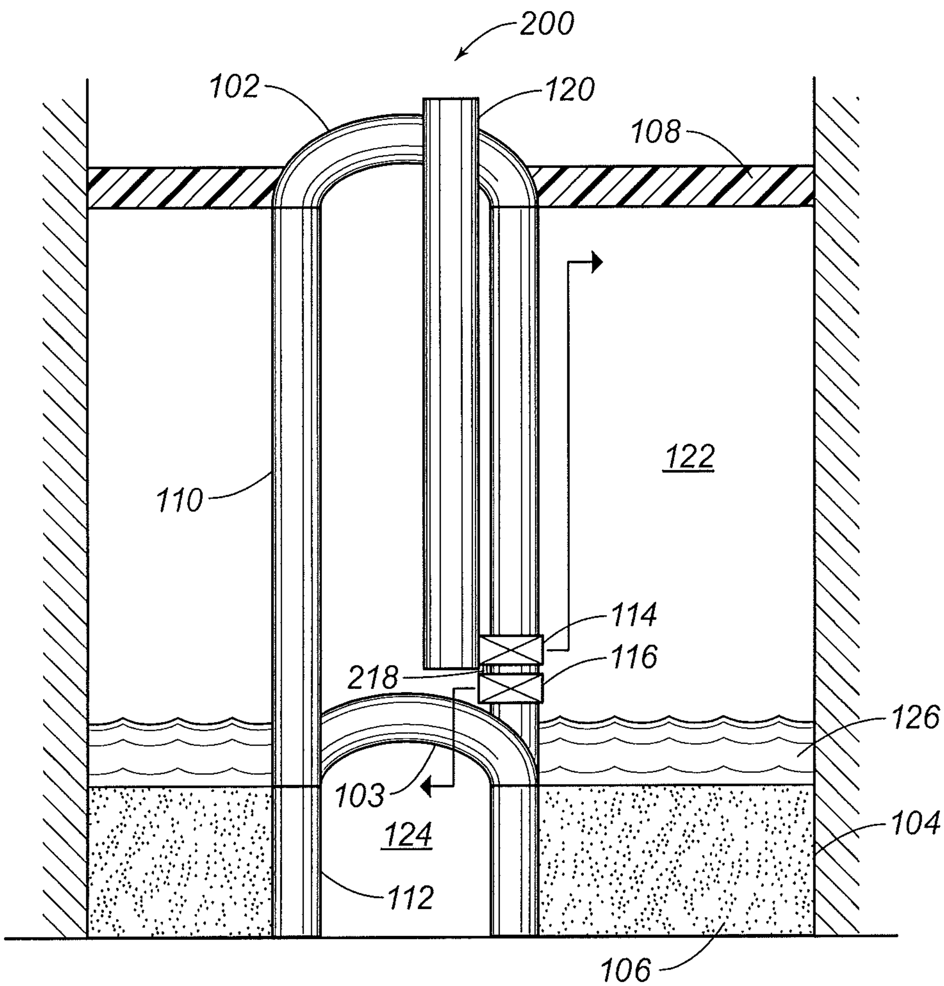

FIG. 2

CASING JOINT ASSEMBLY FOR PRODUCING AN ANNULUS GAS CAP

CROSS-REFERENCE TO RELATED APPLICATIONS

The priority of PCT Patent Application No. PCT/US2013/54075, filed on Aug. 8, 2013, is hereby claimed, and the specification thereof is incorporated herein by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

Not applicable.

FIELD OF THE DISCLOSURE

The present disclosure generally relates to a casing joint assembly and methods for producing an annulus gas cap using the casing joint assembly.

BACKGROUND

A natural resource such as oil or gas residing in a subterranean formation can be recovered by drilling a well into the formation. The subterranean formation is usually isolated from other formations using a technique known as cementing. In particular, a well bore is typically drilled down to the subterranean formation while circulating a drilling fluid through the well bore. After the drilling is terminated, a string of pipe (e.g. casing string) is run in the well bore. Primary cementing is then usually performed whereby a cement slurry is pumped down through the casing string and into the annulus between the casing string and the wall of the well bore or another casing string to allow the cement slurry to set into an impermeable cement column and thereby fill a portion of the annulus. Sealing the annulus typically occurs near the end of cementing operations after well completion fluids, such as spacer fluids and cements, are trapped in place to isolate these fluids within the annulus from areas outside the annulus. The annulus is conventionally sealed by closing a valve, energizing a seal, and the like.

After completion of the cementing operations, production of the oil or gas may commence. The oil and gas are produced at the surface after flowing through the casing string. As the oil and gas pass through the casing string, heat may be passed from such fluids through the casing string into the annulus. As a result, thermal expansion of the fluids in the annulus above the cement column causes an increase in pressure within the annulus also known as annular pressure buildup. Annular pressure buildup typically occurs because the annulus is sealed and its volume is fixed. Annular pressure buildup may cause damage to the well bore such as damage to the cement sheath, the casing, tubulars, and other equipment. In addition, annular pressure buildup makes proper casing design difficult if not impossible. Because the fluid pressures may be different in the annulus for each well bore, use of a standard casing design may not be practical. In order to control annular pressure buildup, conventional methods circulate gas into place during cementing operations. Because the gas is mobile, it is difficult to place the gas in the proper location and, at the same time, control the fluid pressure in the annulus. If, for example, the gas is placed too far below the top of the annulus, the rising gas will increase the pressure in the annulus.

Other techniques to control annular pressure buildup include pressure relieving/reducing methods, such as using syntactic foam wrapping on the casing string, placing nitrified spacer fluids above the cement column in the annulus, placing rupture disks in another, outer, casing string, designing "shortfalls" in the primary cementing operations, such as designing the top of the cement column in an annulus to be short of the previous casing shoe, and using hollow spheres. However, such techniques have drawbacks. For instance, the syntactic foam may cause flow restrictions during primary cementing operations. In addition, the syntactic foam may detach from the casing string and/or become damaged as the casing string is installed. Drawbacks with placing the nitrified spacer fluids include logistical difficulties (e.g., limited room for the accompanying surface equipment), pressure limitations on the well bore, and the typical high expenses related thereto. Further drawbacks with placing the nitrified spacer fluids include loss of returns when circulating the nitrified spacer into place and in situations wherein the geographic conditions provide difficulties in supplying the proper equipment for pumping the nitrified spacer. Additional drawbacks include failure of rupture disks that may prevent well bore operations from being able to proceed. Further drawbacks include the designed "shortfall," which may not occur due to well bore fluids not being displaced as designed and cement channeling up to a casing shoe and trapping it. Moreover, problems with the hollow spheres include the spheres failing before placement in the annulus.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure is described below with references to the accompanying drawings in which like elements are referenced with like reference numerals, and in which:

FIG. **1** is a cross-sectional, elevation view illustrating a well bore and an upper end of a casing string comprising one embodiment of a casing joint assembly for producing an annulus gas cap.

FIG. **2** is a cross-sectional, elevation view illustrating a well bore and an upper end of a casing string comprising another embodiment of a casing joint assembly for producing an annulus gas cap.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present disclosure therefore, overcomes one or more deficiencies in the prior art by providing a casing joint assembly and methods for producing an annulus gas cap using the casing joint assembly.

SUMMARY OF THE INVENTION

In yet another embodiment, the present disclosure includes a method for producing an annulus gas cap, which comprises: i) lowering a work string into a casing string and through one end of a casing joint assembly; ii) connecting the work string to a first valve or a second valve and a valve actuator; iii) opening the first valve and the second valve using the work string and the valve actuator; iv) injecting a compressible gas through the work string and the first valve or the second valve into an annulus between a well bore wall and the casing joint assembly to form the annulus gas cap; and v) displacing a portion of a fluid in the annulus through the first valve or the second valve into another annulus in the casing string.

In the following detailed description of the preferred embodiments, references to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific preferred embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments that may be utilized and that logical changes may be made without departing from the spirit and scope of the present disclosure. The claimed subject matter thus, might also be embodied in other ways, to include structures, steps and combinations similar to the ones described herein, in conjunction with other present or future technologies. The following detailed description is therefore, not to be taken in a limiting sense, and the scope of the present disclosure is defined only by the appended claims.

Referring now to FIGS. **1-2**, the cross-sectional, elevation views illustrate different embodiments of a casing joint assembly **100**, **200** for producing an annulus gas cap. An upper end of a casing string comprises the casing joint assembly **100**, **200** which is open at one end **102** and is connected to a casing joint **112** at another end **103**. Alternatively, the casing joint assembly **100**, **200** may be connected at the one end **102** to another casing joint (not shown) when the casing joint assembly **100**, **200** is not positioned at the upper end of the casing string. The casing string is substantially secured within a well bore by a cement column **106** positioned around the casing string near the another end **103** of the casing joint assembly **100**, **200**. The casing joint assembly **100**, **200** comprises a casing joint wall **110**, a first valve **114**, a second valve **116** and a valve actuator **118**, **218**. The first valve **114** is preferably positioned above the second valve **116**, however, the first valve **114** may be positioned below the second valve **116**. The first valve **114** passes through an opening in the casing joint wall **110** and restricts fluid communication between a sealed annulus **122** in the well bore and an annulus **124** in the casing string. Likewise, the second valve **116** passes through an opening in the casing joint wall **110** and restricts fluid communication between the sealed annulus **122** in the well bore and the annulus **124** in the casing string. The first valve **114** and the second valve **116** may be any conventional valve suitable in size and operation for the purposes described herein such as, for example, valves used in staged cementing operations. The first valve **114** and the second valve **116** are connected by the valve actuator **118**, **218**, which may be any conventional mechanical, pneumatic, hydraulic and/or electric actuator capable of opening the first valve **114** and the second valve **116** at the same time or at different times and closing the first valve **114** and the second valve **116** at the same time or at different times. The casing joint wall **110** is preferably the same size and dimension as every other casing joint wall in the casing string, however, may vary therefrom for purposes of stability, receipt of the first valve **114** and the second valve **116**, and separation of the first valve **114** and the second valve **116**. The casing joint assembly **100**, **200** therefore, may be made from any conventional casing joint using conventional valves and valve connections with minor adjustments in size and/or dimension.

The sealed annulus **122** in the well bore is formed by the casing joint wall **110**, which includes the first valve **114** and the second valve **116**, the cement column **106**, a wall **104** of the well bore or another casing string (not shown), and a seal assembly **108**. The seal assembly **108** may be positioned around the one end **102** of the casing joint assembly **100**, **200** to prevent fluid communication between the sealed annulus **122** in the well bore and the annulus **124** in the casing string other than through the first valve **114** and the second valve **116**. Alternatively, the seal assembly **108** may be positioned anywhere around the casing string above the casing joint assembly **100**, **200** for the same purpose when the casing joint assembly **100**, **200** is not positioned at the upper end of the casing string. The seal assembly **108** may be any conventional mechanical means capable of preventing fluid communication between the sealed annulus **122** in the well bore and the annulus **124** in the casing string other than through the first valve **114** and the second valve **116**. For example, a conventional packer may be used for the seal assembly **108**. After conventional cementing operations, the sealed annulus **122** in the well bore contains drilling fluid **126**. The drilling fluid **126** substantially fills the sealed annulus **122** in the well bore and increases pressure in the sealed annulus **122** due to thermal expansion of the drilling fluid **126** in the sealed annulus **122**. Because drilling fluid is not very compressible, pressures as high as 10,000 psi above the hydrostatic pressure have been predicted. In conventional casing strings, the increased fluid pressure in the sealed annulus between the casing string and a wall of the well bore or another casing string make proper casing design difficult if not impossible. As demonstrated by the following description of the use and operation of the casing joint assembly **100**, **200**, fluid pressures and temperatures in the sealed annulus **122** may be substantially controlled and maintained.

In operation, a work string **120** is lowered into the casing string through the one end **102** of the casing joint assembly **100**, **200** after cementing operations. The work string **120** is then connected to the first valve **114** and the valve actuator **118**, **218** by any mechanical means well known in the art. The work string **120** is used to open the first valve **114** and the second valve **116** with the valve actuator **118**, **218**. Although the work string **120** is connected to the first valve **114** in FIGS. **1-2**, it may be connected to the second valve **116** to perform the same functions in substantially the same manner as described in reference to FIGS. **1-2**. The work string **120** may be any tubular member or regular drill string tubing with the mechanical means at a lower end to connect to the first valve **114** and the valve actuator **118**, **218**. A compressible gas such as, for example, nitrogen, neon, argon or helium or a foam is injected into the work string **120** from a source at a surface of the well bore, which enters the sealed annulus **122** in the well bore through the opened first valve **114**. Other non-corrosive, inexpensive gases may be used, however, nitrogen is preferred. The drilling fluid **126** in the sealed annulus **122** is displaced by the gas or foam as the gas or foam enters the sealed annulus **122** in the well bore. The displaced drilling fluid **126** thus, enters the annulus **124** in the casing string through the opened second valve **116**.

The first valve **114** and the second valve **116** may be positioned farther apart as illustrated in FIG. **1** compared to the position of the first valve **114** and the second valve **116** in FIG. **2**. The casing joint assembly **200** in FIG. **2** thus, requires the gas or foam injected into the sealed annulus **122** to travel up through the drilling fluid **126** until the drilling fluid **126** is substantially displaced. Conversely, the casing joint assembly **100** in FIG. **1** does not require the gas or foam injected into the sealed annulus **122** to travel up through the drilling fluid **126** until the drilling fluid **126** is substantially displaced. The gas or foam injected into the sealed annulus **122** may, however, be required to travel up through the drilling fluid **126** until the drilling fluid **126** is substantially displaced if the seal assembly **108** is positioned anywhere around the casing string above the casing joint assembly **100** in FIG. **1**. In either embodiment, a known amount of drilling fluid **126** will remain in the sealed annulus **122** below the second valve **116** as shown in FIGS. **1-2**. Therefore, the position of the second valve **116** is preferably as low as possible in the casing joint wall **110**.

After a predetermined amount of gas or foam is injected into the sealed annulus **122**, which cannot exceed the volume of the sealed annulus **122** above the second valve **116** and is preferably equal to the volume of the sealed annulus **122** above the second valve **116**, the first valve **114** and the second valve **116** are closed by the work string **120** with the same means used to open the first valve **114** and the second valve **116**. In this manner, a gas cap is created in the sealed annulus **122**. Because the sealed annulus **122** is a known volume at a known position in the well bore, the annulus gas cap may be properly positioned and used to substantially control and maintain fluid pressures and temperatures in the sealed annulus **122**.

While the present disclosure has been described in connection with presently preferred embodiments, it will be understood by those skilled in the art that it is not intended to limit the disclosure to those embodiments. It is therefore, contemplated that various alternative embodiments and modifications may be made to the disclosed embodiments without departing from the spirit and scope of the disclosure defined by the appended claims and equivalents thereof.

The invention claimed is:

1. A method for producing an annulus gas cap, which comprises:

lowering a work string into a casing string and through one end of a casing joint assembly;

connecting the work string to a first valve or a second valve and a valve actuator;

opening the first valve and the second valve using the work string and the valve actuator;

injecting a compressible gas through the work string and the first valve or the second valve into an annulus between a well bore wall and the casing joint assembly to form the annulus gas cap; and

displacing a portion of a fluid in the annulus through the first valve or the second valve into another annulus in the casing string.

2. The method of claim **1**, further comprising closing the first valve and the second valve using the work string and the valve actuator.

3. The method of claim **1**, further comprising controlling at least one of a pressure and a temperature in the annulus with the compressible gas.

4. The method of claim **3**, wherein the at least one of the pressure and the temperature are controlled in the annulus by closing the first valve and the second valve after injecting a predetermined amount of the compressible gas into the annulus.

5. The method of claim **3**, wherein the at least one of the pressure and the temperature are controlled in the annulus by displacing the portion of the fluid in the annulus until the fluid in the annulus is substantially displaced.

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